

[Translation from German]

**Method of producing LED bodies
with the aid of a cross-sectional constriction**

Description:

Method of producing light-conducting LED bodies of a material that is free-flowing before final solidification, by introduction into a mold, where the individual LED body comprises at least one light-emitting chip and at least two electrodes - connected electrically with the chip - and where the free-flowing material is injected between a floor region of the mold and the chip, at least approximately parallel to the chip plane and at least approximately normal to a plane formed by two electrodes, between the electrodes.

DE 101 59 522 discloses a method of this kind for producing light-emitting diodes. The diode to be produced is a radial LED, whose mold is filled by radial injection of free-flowing material. The material is injected under the chip normal to a plane established by the electrodes. In this method, the material filling the mold flows from below around the chip and the bonding wire placed over it. By this method the bonding wire is protected from being torn off by the incoming material. However, it frequently happens that - viewed in the direction of injection of material - the material introduced into the mold piles up on one side before or after the electrodes. As a result, the flow front flowing predominantly toward one side of the chip can push the bonding wire aside hard enough to cause it to come

into contact with the cathode. As further flow toward the diode takes place, the component fails due to short circuit.

The present invention therefore is based on the problem of developing a method of producing light-conducting LED bodies in which, at customary output capacities of known injection or molding operations, the LED electronics are not adversely affected.

This problem is solved by the features of the main claim. For this purpose, the volumetric flow of a free-flowing material, at a distance of the electrode plane from the charging point that is greater than 30% of the distance between the charging point and the mold side of the mold lying opposite the charging point – is choked above the charging point and below the chip plane on the mold side of the charging point by at least one cross-sectional constriction, while - at a distance that is smaller than or equal to 30% of this distance - choking takes place on the mold side lying opposite the charging point.

By this method of producing a luminescent diode, a given specification of the charging point and of the direction of introduction in conjunction with a prescribed choking of the volumetric flow of material at a defined spot procures a flow condition that permits controlled, uniform filling of the mold without any damage to the LED electronics. For choking, a molding element that narrows the cross section of flow between the front edge of the molding element and the chip is located in the individual mold cavity opposite the electrode fence. The geometric dimension of the molding element and its surface structure turned toward the volumetric flow is selected according to the type of synthetic material,

or as necessary. This is simple to accomplish with the use of replaceable choke slides bearing the molding element.

The molding element causes the in-flowing material to be choked at least on one side in such a way that the flow fronts moving from below against the chip on both sides of the electrodes contact and flow around the chip and the bonding wire virtually simultaneously. The virtually simultaneous envelopment of the bonding wire stabilizes the bonding wire in its structurally preplanned position.

The method is likewise applicable to luminescent diodes having a plurality of chips and electrodes.

Additional details of the invention appear in the subclaims and the following description of a number of exemplary embodiments represented schematically.

- Figure 1: LED mold with cross-sectional constriction over the point of injection;
- Figure 2: LED mold with cross-sectional constriction opposite the point of injection;
- Figure 3: Side view of an LED in a mold with the molding element slide driven in;
- Figure 4: Front view of the LED in Figure 3;
- Figure 5: Top view of LED fabrication connections near the injection molding nozzles;
- Figure 6: View from below of the LED in Figure 1 with a plurality of parting lines;

Figure 7: Side view of an LED in a mold with the molding element slide driven out;

Figure 8: Top view of Figure 7, largely without mold.

Figures 3 to 6 show an LED (10) whose light-conducting body (20) is produced for example by molding in one injection molding step.

Here the LED (10) represented has an LED body (20) theoretically divided into two zones (21, 41), cf. Figure 4. The lower zone (41) of the body (20) is a so-called electronics protective zone, while the upper zone (21) is designated a light-conducting zone. The two zones are separated from each other by an imaginary parting line (39). The parting line (39) is represented dash-dotted only in Figure 4.

The electronics protective zone (41) as a rule surrounds the electrical connections (1, 4) lying in a plane (19), the light-emitting chip (6), a bonding wire (2) and a reflector basin (5). The latter for example is part of the cathode (4). The chip (6) sits in the reflector basin (5). The chip (6) contacts the anode (1) via the bonding wire (2). There the bonding wire (2) preferably lies in a plane (19), which is established by the center lines of the electrodes (1, 4). The light-conducting zone (21) lying above the chip carries the light emitted by the chip (6) as loss-free as possible to the outer surface (14, 15) of the LED (10).

With respect to its spatial design, the LED body (20) of the exemplary embodiment consists of three geometric bodies (11, 14, 15) placed side by side. The lower geometric body (11) is at least approximately a straight cylinder with two at least approximately parallel faces and for example two plane flattenings

(12, 13). The flattenings (12, 13) are parallel to the longitudinal axis (18) of the LED and together enclose a right angle. One flattening (12) is parallel to the electrode plane (19), formed by the center lines of the electrodes (1, 4). The lower face forms the so-called floor region (42). The upper face connects to an upright truncated cone (14), which tapers away from the cylinder (11). A dome (15) sits on the truncated cone (14) as the third geometric body. A tangential transition between the dome (15) and the truncated cone (14) is found for example in the LED longitudinal section.

In the exemplary embodiment, the larger face diameter of the truncated cone (14) measures about 5 mm. It is termed the base size. The taper of the truncated cone (14) is for example 20% of the base size. The total height of the LED (10) corresponds to about 180% of the base size. The height of the cylinder (11), which as a flange-like collar with respect to its radius projects over the truncated cone by about 10% of the base size, measures about 30% of the base size. The depth of the flattenings (12, 13) amounts to about 8% of the base size.

The region of the truncated cone (14) lying above the chip (6) and the dome (15) form the main outlet area.

For LED fabrication the electrodes (1, 4) are part of an as a rule flat, punched, so-called electrode fence (80). Within this fence the electrodes (1, 4) are continuously connected together via crosspieces (81). A fence (80) contains for example 32 electrodes for 16 LEDs (10). The minimum distance apart of the LEDs (10) integrated side by side in the fence (80) amounts to at least 10% of the maximum diameter and/or maximum width of the individual LED (10) in the

electrode or fence plane (19). In the exemplary embodiment, the distance apart of the center lines (18) of two neighboring luminescent diodes (10) amounts to about 150% of the base size.

For the injection molding of LEDs (10), a multiple-part mold (61-63) is used, which together with the injection molding nozzle (71) specifies the design of the luminescent diode (10). The major part of the diode (10) to be fabricated is comprised of a slide mold (62). The latter for example forms a seamless main outlet area and the part of the peripheral areas of the electronics protective zone (41) which is turned away from a neighboring base mold (61). The floor region (42) and the remaining peripheral areas of the LED (10), with the exception of a suction channel (66) and the injection molding nozzle system, are locked by the base mold (61) and a lift mold (63), where for example a choke slide (31) is integrated in the base mold (61) of Figures 3 – 8.

The base mold (61) for example is one of the fundamental elements of the injection molding tool. Here, it is fastened to the stationary part of the tool and is not moved upon ejection. It has a recess (73) into which the injection molding nozzle (71) projects sealingly.

In the base mold (61), according to Figures 3 - 8, for each mold cavity (60) a choke slide (31) is inserted into a channel (91), which here is rectangular. The choke slides (31) are joined together for example in their back regions via crosspieces, cf. Figures 5 and 8. The direction of movement of the choke slides (31) for example is oriented parallel to the floor region (42) of the LED (10) and normal to the electrode fence (80). With regard to the luminescent diode (10),

the upper side of the respective free end of a choke slide (31) is on or just below the chip plane (7).

Depending on the spatial conditions in the mold (61-63), the choke slide (31) may alternatively enclose an angle of 5 to 45° with the electrode fence plane (19). Optionally, the choke slide (31) may alternatively be moved by a pivoting or helical motion within the mold (61-63).

The end of the choke slide (31) projecting into the cavity (60) is termed a molding element (32). Its face turned toward the LED center line (18) is for example a curved spatial surface (33), which corresponds exactly to the cross-sectional area that is produced in a spatial section between the truncated cone (14) and the channel (91), i.e., the curvature corresponds to that of the convex surface of the outer surface (14). In the plane of the drawing of Figure 3 - i.e., in the longitudinal section - the molding element (32) has a trapezoidal cross section. The shearing action of the trapezoidal cross section with respect to the LED center line (18) here corresponds to the angle of the truncated cone (14). In the horizontal top view, cf. Figure 5 bottom, the surface of the molding element (32) projecting into the cavity (60) is shown hatched. The curved edging of this surface (34) oriented to the LED center line (18) represents the upper edge (36) as a circular arc section.

This upper edge (36), which at the same time is the front edge of the molding element (26, 28, 32), may have any desired curvature, not necessarily plane. In addition, it is capable of being equipped with a flow-influencing structure

projecting into the volumetric flow. The structure may be a fluting, a corrugated profile, a knob structure or the like.

In the exemplary embodiment of Figures 3 and 7, the choke slide (31) adjoins the slide mold (62) regionwise.

In Figure 1, instead of the choke slide (31), a projection (26) projects into the cavity (60). The projection (26) is part of the base mold (61). The longitudinal-section contour (35) of this projection and/or molding element encloses a 24°-angle with the LED center line (18).

According to Figure 3, the lift mold (63) is located opposite the base mold (61). According to this representation, for ejection the former is moved away from the base mold (61) toward the right. When the mold (61-63) is closed, the mold parts (61) and (63) touch in a parting line (65) represented in Figure 6. The parting line (65) is divided in the region between the electrodes (1, 4) to form an aperture (67). The aperture (67) is an edge of the suction channel (66) contacting the floor region (42), cf. Figure 3. The suction channel (66) is displaced with respect to the electrode plane (19) by several tenths of a millimeter away from the injection molding nozzle (71).

A hold-down device (69) is located in the lift mold (63). The hold-down device (69) is supported displaceable there - for example in the direction of the opening lift of the mold. It clamps the electrode fence (80) against the base mold (61).

The slide mold (62) moves on the plane formed by the mold parts (61, 63), on which the later floor region (42) of the LED (10) rests, and on the contour of

the base mold (61) surrounding the injection molding nozzle (71). Between the slide mold (62) and the base mold (61) lies a spatially stepped parting line (64).

The slide mold (62), which surrounds the major part of the future LED surface, is penetrated by at least one tempering channel (68), in order to temper the mold and the other tool parts surrounding it by means for example of water or oil at for example 40-160°C. In Figure 3, the slide mold (62) is represented only by way of example as one part. For the case that the diode-shaping part is seated within the slide mold (62) in a separate slide support, the latter may alternatively be equipped with the tempering channel. According to Figure 2, the slide mold (62) optionally bears a projection (28). Its upper edge alternatively lies on or below the chip plane (7).

In preparation for injection molding, the mold (61-63) is opened. For this purpose, the mold parts (63, 69), according to Figure 3, are moved away to the right. The slide mold (62) is driven by means of a guide, not represented - at an angle of for example 25° with respect to the injection molding nozzle center line (75) - obliquely toward the right above to the side. The electrode fence (80), equipped with the chip (6) and the corresponding bonding wires (2), is inserted and centered on the base mold by index pins, not represented. For closing the mold (61-63), the lift mold (63) moves on to the base mold (61). The hold-down device (69) seated in it continues to travel in the direction of closing until the electrode fence (80) is firmly clamped to the base mold (61). By way of example, at the same time the slide mold (62) moves to the molds (61) and (63). The choke slide (31) is now pushed into the cavity (60) so far that the cross-sectional

area (30) of the narrowest point between the electrode fence (80), represented hatched in Figure 5, has reached its minimum. Here, the reduction in cross section may amount to 20 - 80% of the original cross section.

The cavity of the mold (61-63) to be injected with free-flowing material is evacuated via the suction channel (66) and for example via the gap between the lift mold (63) and the hold-down device (69). The vacuum is maintained during the entire injection molding process.

Immediately after evacuation, the hot free-flowing material (8) or (9) is introduced into the corresponding cavity of the mold (61-63) via the respective injection molding nozzle (71), for example a so-called torpedo nozzle. The center line (75) of the injection molding nozzle (71) and of the stream emerging from it is here aligned normal to the electrode plane (19). It lies between the floor region (42) and the lowermost point of the reflector basin (5). In the exemplary embodiment the center line (75) is located at half the height of the cylinder (11). At the same time, it runs midway between the electrodes (1, 4), cf. Figures 5 and 8.

According to Figure 2, during the injection molding operation, the liquid synthetic material (8), for example a transparent, optionally colored thermoplastic capable of injection, such as modified polymethylmethacrylimide (PMMI), is shot into the evacuated, tempered mold (61-63) at a pressure of 700 ± 300 bar. The flow rate is for example 0.2 to 10 millimeters per second. The stream passes the electrodes (1, 4) displaced toward the charging point (70) - by a distance calculated from the difference between the inside distance (86) and the distance

(85) - midway and divides at the wall of the mold (62) lying opposite the charging point (70). In doing so, the stream loses so much energy that the incoming synthetic material, upon filling up the cavity, cf. Figure 1, flows from below upward before and after the electrode plane (19). Choking of the volumetric flow produced by the projection (28) forces an approximately uniform movement upward of the flow front (92-95) in front of and behind the electrode fence (80). Between the positions (94) and (95) of the flow front, the rapidly flowing material (8) reaches the bonding wire (2) before and after the electrode fence (80) at the same time and with a direction of flow that runs parallel to the LED center line (18). The flow proceeds around the bonding wire (2) without altering its prescribed position. The bonding wire (2) is neither pushed to the side nor torn off.

If the material (8) or (9) is introduced into a mold in which the electrodes (1, 4) or the electrode plane (19) are or is moved from the charging point further than 35% of the distance (86) between the mold sides (78) and (79), for example at a central position within the mold (61-63), molding elements (26, 32) that lie directly above the charging point (70) are used for choking the volumetric flow, cf. Figures 1, 3 and 7. Here, the material (8, 9) piles up before the electrode fence (80) and moves - without a corresponding molding element (26, 28) - faster upward there than behind the fence (80). When the molding elements (26, 32) are used, the respective material (8, 9) moves, at least in the region of the bonding wire (2), past the chip (6) at virtually the same time. In this flow around the chip, the optimal position of the bonding wire (2) likewise is not altered.

In the device of Figures 3 - 8, after complete preliminary filling of the mold, the pressure of the material is maintained and the choke slide (31) pulled back all the way to the outer contour (14) of the LED (10). As a result, the space freed up by the choke slide (31) fills up.

After injection molding and ejection, in a separating operation the crosspieces (81) between the luminescent diode (10) and the electrodes (1, 4) of the individual LEDs (10) are removed by for example stamping.

List of reference numerals

1	Connection, anode, electrode
2	Bonding wire, aluminum wire
4	Connection, cathode, electrode
5	Reflector basin
6	Chip
7	Chip plane
8	Material, thermoplastic
9	Material, pressure-setting material, epoxy resin
10	LED, luminescent diode, diode
11	Cylinder, flange-like collar
12, 13	Flattenings
14	Truncated cone, outer contour
15	Dome
16	Shape of injection molding nozzle
18	LED center lines, LED longitudinal axes
19	Electrode plane, fence plane
20	LED body
21	Light-conducting body
22	1 st flow front to (26)
23	2 nd flow front to (26)
24	3 rd flow front to (26)
25	4 th flow front to (26)
26	Projection, molding element on (61)
28	Projection, molding element on (63)
30	Cross-sectional constriction, choke point, cross-sectional area
31	Slide, choke slide

32	Molding element
33	Spatial surface, curved
34	Area of molding element that projects into (60)
35	Contour, contour of longitudinal section
36	Upper edge
38	Parting line between (61) and (31)
39	Parting line, imaginary, between (21) and (41)
41	Electronics protective zone
42	Floor region
60	Mold cavity
61	Base mold
62	Slide mold
63	Lift mold
64	Parting line between (61) and (62)
65	Parting line between (61) and (63)
66	Suction channel
67	Aperture
68	Tempering channel
69	Hold-down device
70	Charging point for material (8, 9)
71	Injection nozzles, torpedo nozzles, hot channel nozzles
72	Heating cartridges
73	Recess in (61)
75	Center lines of injection nozzles
78	Mold side on which the injection molding nozzle (71) lies
79	Mold side opposite the injection molding nozzle (71)

- 80 Electrode fence (lead frame strips), flat
- 81 Crosspieces, upper
- 85 Distance between (70) and (81)
- 86 Distance between (70) and (79) in the region of the collar (11)
- 91 Channel
- 92 1st flow front to (28)
- 93 2nd flow front to (28)
- 94 3rd flow front to (28)
- 95 4th flow front to (28)